Comment

Comment on Rodríguez Collantes et al. A New Earth Crustal Velocity Field Estimation from ROA cGNSS Station Networks in the South of Spain and North Africa. *Remote Sens*. 2025, *17*, 704

Juan A. García-Armenteros [1]

[1] University of Jaén, Las Lagunillas Campus, 23071 Jaén, Spain; jgarmen@ujaen.es
† Current address: Department of Applied Geodesy, Aranzadi Science Society, Zorroagagaina 11, 20014 Donostia - San Sebastián, Gipuzkoa, Spain

Abstract: In their recent study, Rodríguez Collantes et al. presented a new GNSS velocity field from the Royal Institute and Observatory of the Spanish Navy (ROA) network, deployed in southern Spain and northern Africa. However, their claims regarding the novelty of certain results and the precision of their findings compared to recent publications are questionable. I present previous studies not cited by the authors, which challenge or contradict these claims and suggest potential bias in their study. Based on these publications, I highlight key differences, contradictions, and shortcomings in aspects such as the GNSS data used, time series analysis, methodological rigor, and geodynamic interpretation. Furthermore, I identify significant errors in both graphical and numerical results, issues affecting the replicability of the methodology, and inconsistencies between the text and its citations.

Keywords: Data quality; GNSS processing; Iberia Morocco region; plate convergence; precision; ROA CGNSS network; time series analysis; velocity field merging

1. Introduction

Rodríguez Collantes et al. [1] recently published an article in Remote Sensing Journal that provides the velocity field obtained from geodetic stations operated by the Royal Institute and Observatory of the Spanish Navy (ROA). These results are of interest to the scientific community as they provide information on new stations that could help in the study of the convergence deformation of the Eurasian–Nubian plates in the western Mediterranean region, which is highly appreciated.

Part of their presentation and conclusions are based on a comparison with publications prior to 2015, which they have referred to as *recent studies*, related to the region under study or to the ROA stations. However, they have not taken into account subsequent publications, which are even more relevant. On the other hand, some of the ROA stations have been analyzed in previous studies concerning their quality, which question the precision of the results or, at the very least, suggest that the quality issues of these stations should be taken into account. Taken together, these works invalidate, contradict, or cast doubt on certain claims, findings, and conclusions presented in [1].

Herein, I address and correct certain statements made in [1] based on these latest works. Additionally, I highlight issues in their methodology, the information provided, and some errors identified. The presentation of the comments is structured into sections, with the identified errors included in the relevant section.

This is a **non-peer reviewed preprint submitted to EarthArXiv**. This manuscript was originally submitted to *Remote Sensing* on March 20, 2025, and is shared here to ensure transparency and accessibility while the editorial assessment is ongoing. If accepted, the final version of this manuscript will be available via the *'Peer-reviewed Publication DOI'* link on the right-hand side of this webpage

2. Comments and corrections

2.1. Previous publications

Rodríguez Collantes et al. [1] made statements such as *"For the first time, the displacement velocities of the ROA CGNSS stations have been estimated [...]"*, *"The obtained velocities have been compared with other recent studies in this field that included data older than 10 years [...]"*, and *"The most updated studies in the GNSS field in this region, mainly in North Africa, include campaigns with data from continuous stations up to 2014, such as those presented in the Topo-Iberia project"*. However, the displacement velocities of the ROA stations have been estimated for quite a few years, although it is true that this is the first time that it has been done considering all the ROA stations. Furthermore, it is incorrect to state that the most updated studies in this region include data from continuous stations up to 2014. The authors have ignored the work published on 28 June 2023 [2], whose preprint [3] was posted on 29 June 2022. This publication provides the horizontal cortical velocity field derived from Global Positioning System (GPS) data of the Topo-Iberia network (2008–2019), as well as the first vertical velocity field derived from these data—one of the few velocity fields available for the Iberian Peninsula and Morocco. This field includes some stations under the control of the ROA (ALJI, BENI, ERRA, LIJA, LOJA, TAZA, and TIOU). Another very relevant publication for the authors in relation to the ROA stations is the quality assessment of the Topo-Iberia stations published in March 2024 [4], available online on 1 October 2023, and whose preprint [5] was posted on 14 February 2023. This is the most comprehensive study of the data quality of these stations conducted to date, including the ROA stations. Additionally, all the yearly quality plots from all stations were made available on the website [6]. Another study related to the quality of these stations, specifically addressing the noise from the geodetic monuments and the effects of the antenna environment, is the preprint posted on 30 January 2024 [7], which is still under review. These studies were compiled in [8], available online on 8 March 2024. Furthermore, all the publications are open access, some of them funded or published by the University of Jaén, an academic and scientific institution present in the author list of [1].

2.2. GNSS data and quality assessment

The term *quality* is not mentioned by Rodríguez Collantes et al. [1]. It is assumed that the authors performed quality checks before processing, although this is only an assumption. The findings of the works [4,7,8] may be useful for understanding the behavior of stations throughout their periods of activity and may constitute a valuable resource for time series analysis. These works indicate that some ROA stations exhibit data quality issues that must be considered, and some of these issues are mentioned below.

Figure 1 shows the GPS data from the Topo-Iberia stations, including the seven ROA stations mentioned above, which were analyzed and processed by García-Armenteros [2]. This representation is based on a preliminary data quality check in relation to the maximum number of complete observations recorded. Furthermore, the recommendations of Blewitt and Lavallée [9] to obtain the minimum velocity bias in relation to the effect of annual signals in velocity estimation were also taken into account. As a result, the available data spans were shortened, prioritizing the elimination of the lowest quality periods, in order to achieve complete years plus an additional half-year. I have mentioned "GPS" in this Figure, instead of GNSS, because the Topo-Iberia stations exclusively record observations from this satellite system. Rodríguez Collantes et al. [1] do not specify whether they also utilized observations from other systems; however, I assume they exclusively used GPS data.

The authors have stated regarding the seven ROA stations mentioned above that *"The key contribution of our study is the inclusion of newly available data over the four-year period analyzed"*. While it is true that the data intervals have generally increased compared to

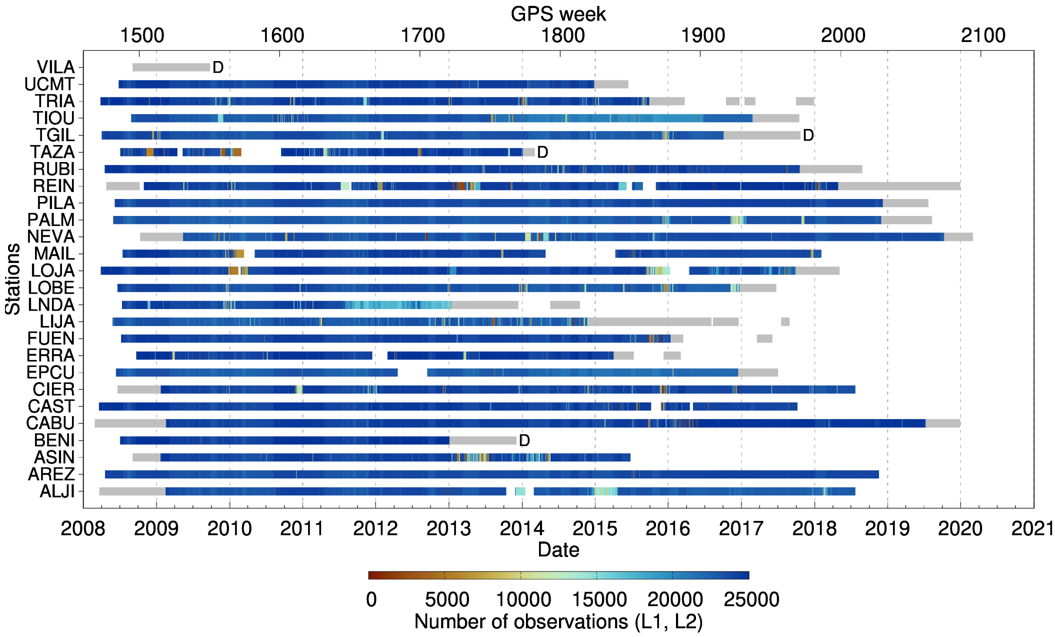


Figure 1. Selected data spans to process and the maximum number of complete observations recorded at each Topo-Iberia CGPS station. The letter D indicates dismantled. Spans in gray correspond to discarded data whose quality can be seen in [2, Suppl. 1 Figure S1]. This Figure is taken from [2].

Table 1. Total spans (in years) of GPS data from ROA stations used in [1,2]. An asterisk symbol indicates the presence of large gaps in the time series.

Station	Total data span (Years)		
	Available[2]	Processed[2]	Processed[1]
ALJI	10.2	9.4	15.7*
BENI	5.3	4.5	5.4
ERRA	7.3	6.5	5.4
LIJA	9.2	6.5	15.3*
LOJA	10.0	9.5	13.0*
TAZA	5.6	5.5	5.6
TIOU	9.0	8.5	15.8

[1] Data considered by Rodríguez Collantes et al. [1].
[2] Data considered by García-Armenteros [2].

those processed by Garate et al. [10], the difference is smaller when considering the most recent previous publications. In some cases, the opposite has even occurred. The Table 1 presents the total data spans in years considered by Rodríguez Collantes et al. [1, Table 1] and García-Armenteros [2, Table S1]. As indicated above and shown in the Figure 1, the data spans were shortened; consequently, less data was processed than was available, which correspond to the second and third columns of the Table. In contrast, the information provided in [1] suggests that all data, from the start of the stations' activity to a specific date, have been processed. The total duration in years is shown in the last column. At first glance, it appears that more data have been processed; however, it is important to highlight certain details of each station that could easily be overlooked:

- ALJI. Although the time series from this station has been extended to the end of 2023 in [1], resulting in a total of 15.7 years, it includes a 6-year gap, i.e., a period without data collection. The time series consists of approximately 6 years of continuous data, a 6-year gap, and 4 years of continuous data [1, Figure A4]. In contrast, [2] processed 9.4 years of continuous data. The authors state that *"ALJI experienced a period of inactivity* *following the Topo-Iberia project[...]"*, but this is not correct as shown in the Figure 1, where the 6-year gap is not appreciated. The authors also state that some stations have experienced communication issues, but they do not mention the significant gaps in some of their position time series, which are highly relevant. If the reader carefully examines the time series graphs in the Appendix, they will be aware of this; however, the authors' presentation creates confusion regarding the time periods provided and the *actual continuity* of the data in the time series. That is, the improvement they claim in relation to the data considered in previous publications. Furthermore, these gaps may present some drawbacks, which are discussed later in the section 2.6.

- LIJA. As in the previous case, the authors have significantly extended the time series to 2023, but with substantial gaps that raise the question of whether the series can be considered continuous since 2016 (Figure 2). The 15.3-year time series consists of approximately 8 years of continuous data, including a small gap, and a 7-year gap, with the exception of small isolated data series. The effort to obtain and provide data is highly valued and appreciated; however, the validity of this data is not always proportional to the effort invested. The authors highlighted the benefits of continuous GNSS observation stations over episodic campaigns, but in this case, even annual episodic campaigns over the last 8 years would be better. The potential consequences for geodynamic interpretation are discussed below (section 2.6). In contrast, the data considered in [2] consisted of 9.2 years of continuous data, which were reduced to 6.5 years after discarding a period with low-quality data.

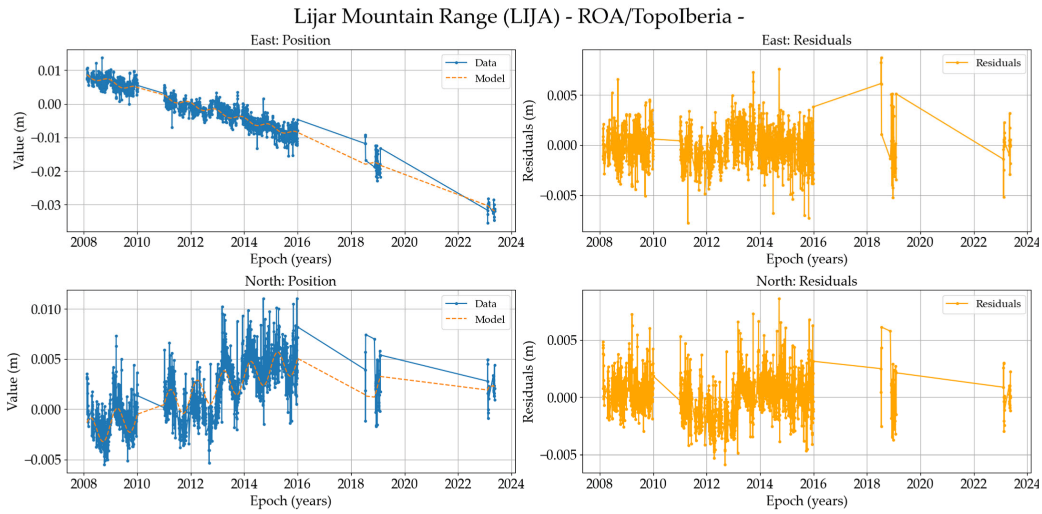


Figure 2. Position time series of the station LIJA (**left**), and residuals of these data (**right**). This Figure is taken from [1].

- LOJA. The authors have extended the time series to 2021/04/13, but this date corresponds to a few isolated data points following periods of data interruptions and 7 years of continuous data [1, Figure A15]. In contrast, [2] processed 9.5 years of continuous data.
- BENI. The authors state that the lastest data corresponds to the date 2014/02/12, but this is not possible, as the station had already been dismantled. Furthermore, the displayed time series does not extend to the year 2014 [1, Figure A7]. Considering this Figure, the data presented in [2] are the same, but the processed span is shorter due to the cropping applied based on the criteria previously outlined. Nevertheless, it is difficult to assess the information provided by Rodríguez Collantes et al. [1], as the graphs displayed for the stations BENI and ERRA are identical [1, Figures A7,A10]. Furthermore, there appears to be a significant error, as the velocity vector resulting

from these graphs corresponds to a southwest orientation, which does not align with the expected displacement at these stations.

- ERRA. The authors also state that the latest data corresponds to 2014/02/12; however, due to the previous error in the graphs, this cannot be verified. Nevertheless, in [2], a longer span (6.5 continuous years) was processed.
- TAZA. The processed period could not be verified as the authors have not provided the time series for this station. However, the period indicated by them is the same as processed in [2].
- TIOU. This is the only case in which the authors have presented a considerable increase in data compared to previous publications; a 7-year increase when considering the last work [2]. However, significant anomalies related to data quality have occurred at this station, which should be taken into account. TIOU has been identified in the latest works on data quality as the station with the worst performance in the Topo-Iberia network, with an overall quality percentage of only 1% [4, Table 3 and Figure 11] and other associated issues [7, Figures 9,18]. The position time series graph is also incorrect in this case, since the authors have presented the same graph for both horizontal components [1, Figure A23].

2.3. Time series analysis

Rodríguez Collantes et al. [1] describe the software used for time series analysis and mention a set of selected options for this purpose. However, they do not specify the exact values chosen for some important options. For instance, the authors state, *"In our case, we entered a file in PBO format (ASCII file with .pos extension) which removes outliers with a residual threshold"*, and *"From among the options, the linear trend was introduced"*. Nevertheless, they do not disclose the value of this threshold. Selecting to remove any position estimate with uncertainty greater than 2 cm in the east or north components is not the same as selecting 5 cm. It is also assumed that after detrending the data, positions exceeding a certain threshold are removed. This information is important because it impacts the level of precision of the results provided, especially in the case of the stations with quality issues mentioned above.

In the position time series graphs, the authors indicate that the graphs on the right represent the residuals of the data. It is not clear, but these are supposed to be the cleaned time series, meaning that outliers and offsets have been corrected and periodic signals have been estimated. If this is the case, a relatively high dispersion in the positions is observed, which suggests that the selected threshold value may be too high. As a result, the dispersion in the daily positions, caused by poor-quality data, is not filtered or removed, thereby affecting the final result. This information regarding the thresholds is necessary for readers to verify and replicate the methodology described by the authors.

Regarding the periodic signals, the authors state that they are modeled using sine and cosine terms. However, in the graphs, it is not clear whether these signals have been correctly estimated by the software, since the periodicity observed in the time series in IGb2020 persists in the residual plots. A straightforward way to verify this would have been to compare the residual time series, both with and without accounting for the periodic signals. Additionally, for stations with large data gaps, such as ALJI, LIJA, and LOJA—where ALJI exhibits one of the strongest periodicities [2, Suppl. 1 Figure S7]—the authors could have evaluated the impact by estimating the periodic signals for the continuous data segments as well as for the entire dataset. This way, the authors could ensure that the periodic signals have been correctly estimated.

Rodríguez Collantes et al. [1] state that *"Appendix A shows the time series of all stations in horizontal coordinates (East and North)"*; however, in addition to the errors previously mentioned in these graphs, the corresponding graphs for the stations ROTA and TARI have not been provided. Furthermore, two stations SFER are presented [1, Figures A21,A22], but information and results are only provided for one. Additionally, the graphs for the station RABT are incorrect, as the same graph is shown for both horizontal components [1, Figure A20].

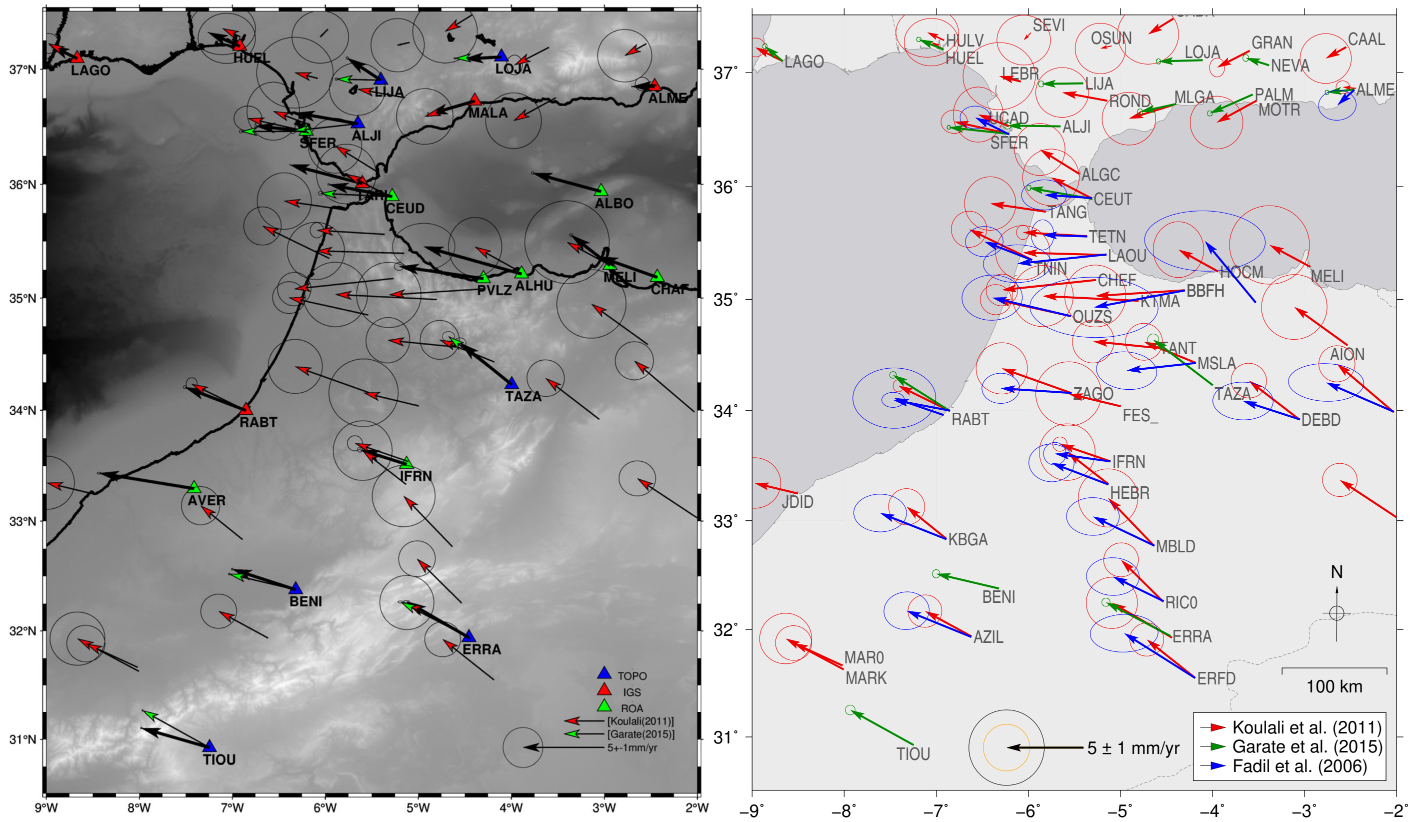
2.4. Reference frame and results validation

To tie the velocity solution to a global reference frame, it is necessary to include an adequate number of continuously operating reference stations (CORS) from international networks in the GNSS processing. A set of ten or more well-distributed CORS with small uncertainties is sufficient to obtain a robust frame realization; and if the Reference Frame Sub-Commission for Europe (EUREF) recommendations are followed, in addition to all the reference stations within the study area, it is recommended to add at least ten CORS surrounding the area [11]. Some advantages of the PPP technique are that it does not require simultaneous observations or nearby CORS stations. Rodríguez Collantes et al. [1] have opted for a reduced number of CORS in the study area, with no surrounding stations to the south. A priori, this is not an issue for the PPP technique; however, among the selected CORS, only the stations ALME and MELI are classified by EUREF [12] as class C0 and C1, respectively; that is, both are recommended as reference stations. The station RABAT is class C3, TARI is class C5, HUEL, LAGO, MALA, and SFER are class C6, the latter being not recommended as reference frame stations. Given the convenience and processing speed of PPP compared to the double-differencing technique, the authors could have opted to include first-order CORS outside the study area. Furthermore, since the authors have based part of their study on comparisons with previous works, including CORS outside the study area would have allowed for a more rigorous comparison, as discussed in the following section.

Regarding the validation of results, the authors indicate that coordinated time series from the stations were uploaded directly from the different GNSS data web servers and were also processed for result verification. However, the authors present the differences between the obtained values and those provided by the International GNSS Service (IGS) only for the station SFER. It is not acceptable to present a validation of results based on a single CORS. If the adjustment for all CORS is not shown, at least the representation of the velocities provided by the IGS and those obtained should be presented. Furthermore, the coordinates obtained for all the stations are also of interest and have not been provided, which hinders or complicates their validation by readers, replication of the methodology, or simply use in future research. Since the authors emphasize the significance of their work by presenting data from some ROA stations for the first time, providing these coordinates becomes even more crucial. There is no space limitation in the Remote Sensing Journal that would prevent providing all this information, and there are no surcharges based on the length of an article or supplementary data. Therefore, this lack of information is unjustified.

2.5. Comparison methodology with previous publications

Rodríguez Collantes et al. [1] state that *"To accurately compare the new insights provided by the analysis of the network used with previous studies in this region, Figure 7 displays the velocities relative to EURA from the most representative prior research, including [4,10,18]"*. I have stated in the Introduction section that the authors have not included the most representative previous research, as they have overlooked studies published after 2015. The works they claim to include are the velocity solutions corresponding to Koulali et al. [13], Garate et al. [10], and Fadil et al. [14], the latter identified by them as reference 18. However, there is no evidence that this last work, published in 2006, has been incorporated into the study. This could be an error or confusion in the citation, but the authors cite it again in the figure



(**a**) (**b**)

Figure 3. (**a**) Map of horizontal velocities of previous publications in a Eurasian-fixed reference frame. This Figure is taken from [1]. (**b**) Map of the horizontal velocities (95% confidence interval) of previous publications [10,13,14] in a Eurasian-fixed reference frame. The orange error ellipse corresponds to the 68% confidence interval.

caption *"Stations included in the study are plotted in black, red[4], and green [10,18] triangles"*. In Figure 3b, the velocity field provided by Fadil et al. [14] is shown, following the same method as in [1], and it is evident that it is not represented in Figure 3a. Furthermore, the authors have not indicated the confidence interval used, but by comparing the Figures, it can be inferred to be 95%. However, by comparing the scale vectors, it can also be inferred that they used the 68% confidence interval, which is not consistent with that used in their velocity field. Regarding the velocity field of Garate et al. [10], it is also noteworthy that the authors did not represent the velocities for the stations RABT, LAGO, MALA, ALME, NEVA, and PALM, with the last two stations being particularly important due to the information they provide on deformation in the Betic Cordillera. A greater number of stations prevents biased geodynamic interpretations and enables the identification of potential anomalous displacements that might go unnoticed when analyzing stations in isolation.

Rodríguez Collantes et al. [1] also state that *"It is true that, when compared with previous studies, it is important to consider that these were conducted in earlier reference frames [51,52], which could introduce a slight displacement; however, given the localized and nearby areas, this effect should be minimal"*. It is highly likely that, in an ideal case where the same velocity solution is represented in both the ITRF2014 and ITRF2020 frames, there would be no noticeable differences in rotation. However, in addition to the fact that the velocity fields were obtained in different reference frames (Koulali et al. [13] in the ITRF2005 and Garate et al. [10] in ITRF2008 frame), it is essential to note that each of the fields was fixed to the global reference system using a different set of CORS. This implies that when the different velocity fields are combined, this *slight displacement* and rotation will most likely be of different magnitudes at each station. Consequently, the phrase *"To accurately compare [...]"* is inconsistent, as the method used is the exact opposite of accurate. This method would be acceptable for an overview, but since the authors base part of their findings and conclusions on this comparison, a more rigorous method is required, such as the method used in [2,10], which employed the VELROT tool from the GAMIT/GLOBK [15] analysis package.

In the case of [2], the individual GPS velocity fields were merged into a common Eurasian-fixed IGb14 reference frame. A six-parameter transformation (rotation and translation) was estimated between each field by minimizing the horizontal velocity residuals at common stations, using the velocity field from [2] as the reference and aligning the other velocity fields with it. The combined velocity fields are depicted in the Figure 4, centered on the Betic-Rif system, where the main differences with respect to previous publications are located. The Table 2 shows the main parameters of this velocity field merging, the number of common stations used in the alignment and the obtained root mean square (RMS) of the fits. The number of common stations, of greater interest if they are CORS, is very relevant for achieving proper alignment and a low RMS fit. If the velocity field of Rodríguez Collantes et al. [1] were used as a reference in the velocity field merge, there would only be six CORS in common with Koulali et al. [13] and Garate et al. [10], and only three with García-Armenteros [2], in addition to not having any CORS surrounding the southern part of the study area. For this reason, it was indicated in the previous section that, although the number of selected CORS in [1] may be valid for PPP processing, it could still be limited if the intention is to conduct objective and rigorous comparisons with previous publications.

Table 2. Individual GPS velocity fields aligned in a common reference frame (velocity field depicted in the Figure 4). An asterisk symbol indicates the number of common CORS.

Velocity field	Initial ref. frame	Final ref. frame	Common station num.	RMS fit (mm/yr)
Koulali et al. [13]	EURA_I05	EURA_I14	11*	0.22
Garate et al. [10]	EURA_I08	EURA_I14	33 (13*)	0.39
García-Armenteros [2]	EURA_I14	EURA_I14	–	–

2.6. Results and geodynamic interpretation

Rodríguez Collantes et al. [1] state regarding the station ALJI that *"[...] the time series showed stability and validity, maintaining the trend observed previously"*. However, in Figure 4 (top), it can be observed that ALJI does not maintain the trend observed in previous works and is in harmony with the surrounding stations, a pattern that becomes even more evident in relation to Nubia (Figure 4, bottom). In the section 2.2, the differences between the data periods considered by [1] and [2] were presented, along with the significant 6-year gap in the former. Furthermore, the station ALJI has exhibited anomalous behavior and is among the three stations identified as having the worst performance in the Topo-Iberia network, with an overall quality percentage of 21% [4]. In general, poor data quality complicates time series analysis, so it is essential to be cautious about their geodynamic implications, particularly when the strain-stress are derived from these results. As mentioned previously, the authors have not provided information regarding the quality of the newly included data. Given the historical performance of the station ALJI in terms of data quality, this information is crucial for evaluating and supporting the results of this station, as well as any other problematic stations.

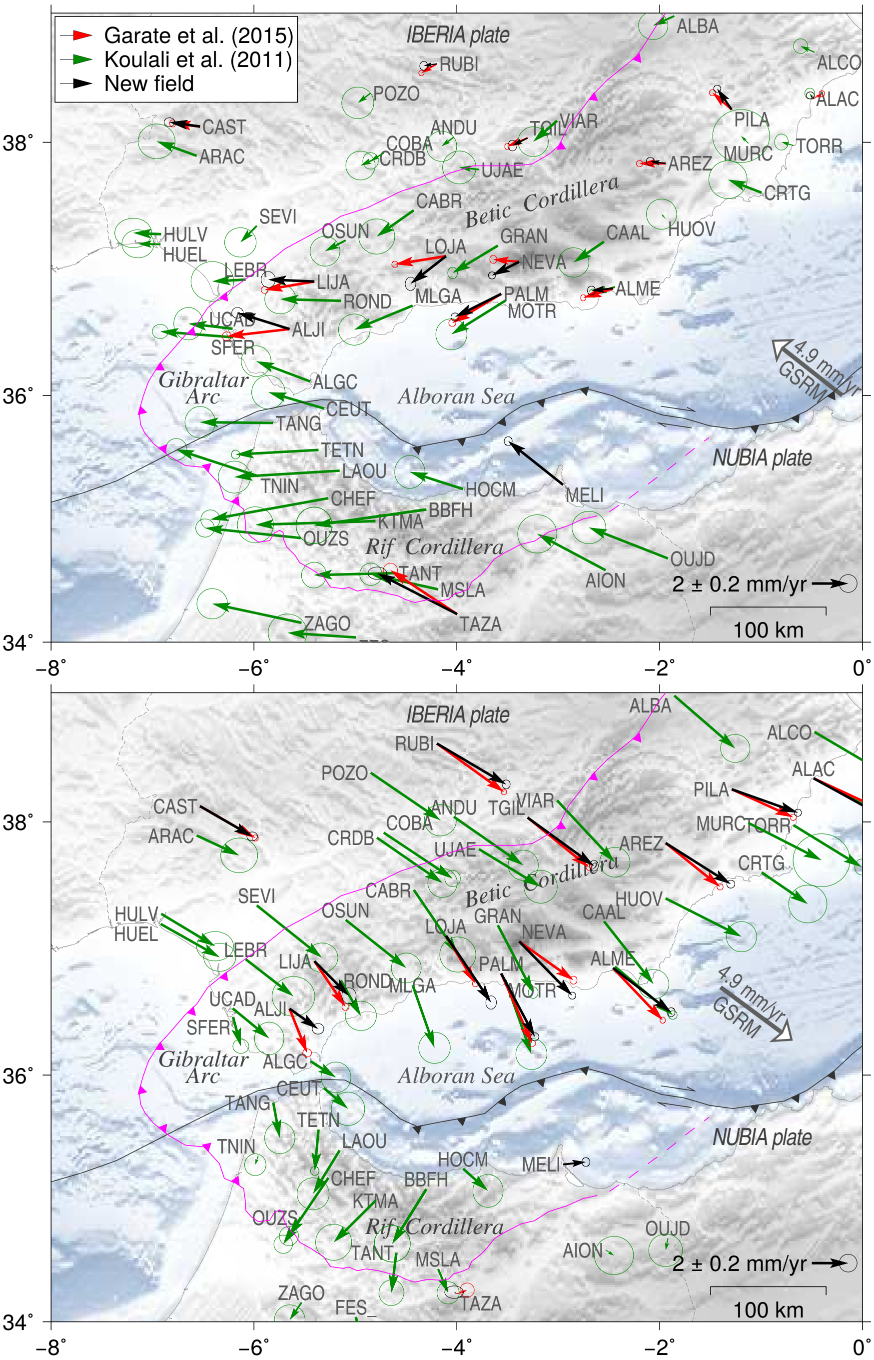


Figure 4. Comparison of the horizontal CGPS velocity field (95% confidence interval) from [2] with previous publications in IGb14, relative to the Eurasian-fixed (**top**) and the Nubian-fixed (**bottom**) reference frames. Note that a factor of 0.5 has been applied to the velocity field uncertainties of Koulali et al. [13] for figure clarity. The magenta and black lines represent, respectively, the Betic-Rif deformation zone and the hypothetical Eurasia-Nubia plate boundary. The gray vector indicates the convergence direction and rate between the plates based on the GSRM v2.1 plate motion model [16]. This Figure is taken from [2], so "New field" in the legend refers to "García-Armenteros (2023)".

Rodríguez Collantes et al. [1] also state that *"However, there are no stations close to LIJA, which shows discrepancies compared to the analyses in [10], presenting a pronounced turn to the north. This may be attributed to the availability of longer time series"*. On the contrary, the result obtained in García-Armenteros [2] does not deviate significantly from that of Garate et al. [10], and is also consistent with those from other stations in the region (Figure 4). Previously, in the section 2.2, the presence of significant gaps in the time series presented by

[1] was highlighted (Figure 2), as well as the addition of some data for the period 2019–2023, which raised doubts about whether it could be considered a *longer time series*. It is worth considering whether the addition of these latter isolated data points provides meaningful information or, on the contrary, masks the true displacement of the station. The authors should have considered the continuous period (2008–2016) separately and evaluated how the inclusion of the latest data and gaps affects the results, as these could lead to unexpected outcomes. Additionally, the quality of the latest data should also be checked. It is likely that future years of continuous and high-quality observation at this station will be necessary to answer this question.

The geodynamic interpretation proposed by the authors for the station LIJA suggests that it is part of a block along with the stations LAGO and HUEL. When analyzed within an Eurasian-fixed reference frame, it is evident that these two stations exhibit lower velocities than the other stations in the Betics. This is primarily due to their location in a more stable region of the Eurasian plate, rendering them less affected by plate convergence. However, I disagree with the authors' statement that LIJA could be part of this block, if we consider its displacement direction, horizontal velocity, and the surrounding stations. Although the results obtained for the stations LAGO and HUEL differ in each of the previous works conducted using different reference systems, when each study is considered individually, the orientation of their velocity vectors either coincides or is very close (Table 3). This suggests that the local deformation at both stations is very similar. It is also consistent across all cases that the orientation of the LIJA velocity vector differs, to a greater or lesser magnitude, from that of the LAGO-HUEL set. When considering an Eurasian-fixed reference frame, the orientation tends to be more towards the north [1] (Figure 3a) or towards the west [2,10] (Figure 4 top), in addition to showing an increase in velocity. Stations such as ROND and ALJI exhibit this velocity increase, representative of the convergence zone in the western sector of the Betics, or a velocity decrease in the case of the Nubian-fixed reference frame (Figure 4 bottom). In Figure 5, the tectonic complexity in the Betic Cordillera has been considered, and rather than calculating a general convergence rate, the average direction and rate relative to the Nubian plate have been determined based on the velocities of the Topo-Iberia stations in the southern half of the Iberian Peninsula. As a result, a northwest-southeast convergence rate of 4 mm/yr has been estimated for the central and eastern sectors of the Betics (blue vector in Figure 5), and 4.1 mm/yr for

Table 3. Horizontal velocity direction of the stations LAGO, HUEL, and LIJA. The azimuth is calculated from the horizontal velocity components provided in the corresponding publication, as indicated in the first column. An asterisk symbol indicates that the reference frame has been modified from the original using VELROT and according to Altamimi et al. [17,18].

GNSS velocity field	**Reference frame**	**Azimuth (°)**		
		LAGO	**HUEL**	**LIJA**
	(Eurasian-fixed)			
Koulali et al. [13]	ITRF2005	297	301	–
Garate et al. [10]	ITRF2008	310	292	269
García-Armenteros [2]	IGb14	–	–	272
Rodríguez Collantes et al. [1]	ITRF2020	296	295	304
EUREF [19]	IGb14	298	298	–
	(Nubian-fixed)			
Koulali et al. [13]	ITRF2005	122	122	–
Garate et al. [10]*	ITRF2008	93	104	138
García-Armenteros [2]	IGb14	–	–	135
Rodríguez Collantes et al. [1]*	ITRF2020	99	101	94

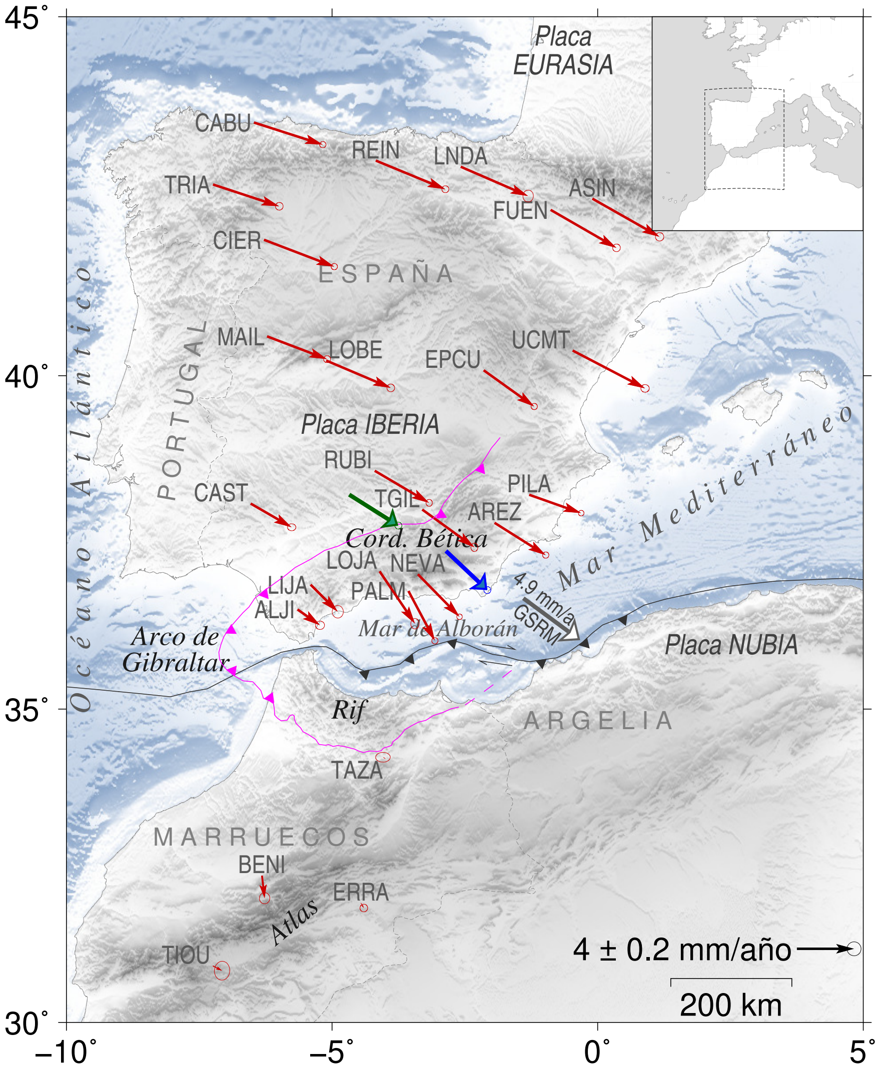


Figure 5. Map of the horizontal velocities (95% confidence interval) of the Topo-Iberia CGPS network in IGb14 (Nubian-fixed) reference frame obtained by [2]. The blue vector represents the average convergence direction and rate in the central and eastern Betic sectors, while the green vector represents these in the adjacent foreland. This Figure is taken from [8].

the adjacent foreland, the most stable strip of this Eurasian plate region (green vector). It is important to note that incorporating a greater number of stations in the area would be necessary to obtain a more precise rate. However, the differences between the central and eastern sectors, compared to the western sector, where the stations LIJA and ALJI are located, are evident.

Rodríguez Collantes et al. [1] state that *"Displacement rates progressively increase toward the south and west, reaching maximum values in the Gibraltar Strait region (SFER, TARI, and CEUD with velocities ranging between 3.5 and 4.5 mm/yr) before gradually decreasing toward the northwestern mountain front (ALJI and ALME showing displacements between 1 and 2 mm/yr)"*. If the values of the horizontal velocity components provided by the authors in [1, Table 3] are correct, then this interpretation is incorrect, as the station ALJI corresponds to a horizontal velocity of 3.9 mm/yr, which is even greater than that of SFER (3.1 mm/yr). It appears that a widespread error has occurred in the calculation of the horizontal velocity, which affects the geodynamic interpretation presented.

Rodríguez Collantes et al. [1] also state that they have processed more than 14 years of data from the station ROTA, but they have not provided the corresponding time series or represented the velocity vector. According to the values in [1, Table 3], this station is notable for exhibiting a northwestward displacement (azimuth of 313°), in contrast to its nearest station, SFER, which exhibits a nearly westward displacement (azimuth of 276°). However, the authors have not analyzed the potential causes of this difference in orientation (causes related to the station, local issues, whether it is consistent with the specific geodynamics of the area, etc.). Since this station is new and its results are being presented for the first time, which is one of the authors' objectives, the results should have been analyzed, even if only preliminary.

Regarding the displacement of the station LOJA, the authors state that it corroborates previous results. However, this differs significantly from the most recent displacement obtained [2], which does not corroborate the previous results, but is consistent with other stations in the region. If the displacement of this station is analyzed alongside the other stations in Figure 4 (top), rather than in isolation as in Figure 3a, it can be observed that the stations NEVA and LOJA exhibit a stronger southwestward component instead of the purely westward motion reported by Garate et al. [10]. Moreover, along with the station PALM, they align well with nearby stations within the velocity field of Koulali et al. [13].

The displacement of the station AVER shown in Figure 3a is oriented northwest, whereas the displacement derived from the provided horizontal velocity components is oriented southwest. One of these is incorrect. Furthermore, the authors state regarding this station that *"The time series from the Averroes station suggests a possible subsidence of the terrain that must be considered in detail"*. However, it is not possible for the time series to suggest such a phenomenon, as the vertical component has not been included. The authors have not considered the study of vertical velocity, and therefore, it is not possible to determine potential subsidence or elevation from the obtained results. On the other hand, the authors suggest that *"One hypothesis may be that it belongs to the Coastal Meseta block, as shown in [20]"*; however, the work identified as reference 20 is focused on the eastern Betic region (SE Spain) [20] and is unrelated to the station AVER or the western region of Morocco. This may again be an error or citation confusion, but if so, it could affect the rest of the citations in a generalized manner.

Rodríguez Collantes et al. [1] state that *"TAZA, located in the Middle Atlas, exhibits a rotation toward the NNW as previously noted, while ERRA, situated within the more stable portion of the NUBIA, displays a distinct pattern"*. In fact, if the values provided in [1, Table 3] are correct, the station TAZA exhibits a velocity vector toward the NW (azimuth of 309°) and the station ERRA presents a slightly more pronounced westward component (azimuth of 300°). Nevertheless, according to the results obtained by [2] for TAZA and ERRA, the azimuths are quite similar, 297° and 295°, respectively.

Rodríguez Collantes et al. [1] also state that *"As we move deeper into the Atlas, the stations show the movement of the NUBIA plate, with a clear NW trend of approximately 4-5 millimeters per year; this is especially verified by TIOU, which have long continuous data series"*. Important issues related to the data quality of the station TIOU have been highlighted in the section 2.2, so caution is advised when using it as a verification tool. While having a longer time series is important, verifying the data quality is essential. However, the authors have not provided any information in this matter.

2.7. Precision of the results

The authors highlight the precision provided by their study, based on a larger dataset compared to previous publications, or in other words, the analysis of longer time series, in addition to processing the data using the PPP technique. It should be noted that the velocity fields in previous publications originate from GNSS processing performed with different software, which in turn involves varying levels of precision: Koulali et al. [13] used the GAMIT/GLOBK software 10.4 [21]; Garate et al. [10] used the Bernese software

5.0 [22], GAMIT/GLOBK 10.4 [21], and GIPSY–OASIS [23]; and García-Armenteros [2] used GAMIT/GLOBK 10.71 [15] and GipsyX software 1.7 [24]. GAMIT/GLOBK and Bernese software use the double-differencing technique, while the GIPSY–OASIS and GipsyX software employ the PPP technique. According to the latest software versions, GAMIT provides a precision of 1–2 mm for horizontal coordinates and 3–5 mm for heights, while GipsyX with PPP and ambiguity resolution offers 2 mm and 6.5 mm, respectively. Rodríguez Collantes et al. [1] indicate that the data processing was performed with PRIDE-PPPAR (PPP with Ambiguity Resolution) software 3.1.2, but they do not explicitly provide the numerical precision, which is crucial information for the reader to better understand the precision of the provided results. Nevertheless, to date, the PPP technique has not surpassed the double-differencing technique in terms of precision.

Moreover, this theoretical precision, which depends on the technique and software used, is likely to be reduced due to factors such as the selected models and processing parameters, the criteria applied in time series analysis, and the continuity, discontinuity, and quality of the data. Consequently, the analyzing of longer time series alone does not inherently improve precision and accuracy; it is essential to consider the other parameters in conjunction.

3. Conclusions

Rodríguez Collantes et al. [1] have recently published a study on the velocity field from the ROA CGNSS network, with implications for the tectonics of the western Mediterranean (southern Spain and Morocco). Many of their findings, statements, and conclusions are based on comparisons with previous publications, which they have described as the most recent or representative works.

In this comment, I show that the authors have not taken into account post-2015 publications related to the velocity field and the quality of the ROA stations. The inclusion of these studies would alter their statements and conclusions. I suggest that the authors incorporate these publications in order to provide a more objective and rigorous study, thus reducing potential bias. It is noteworthy that, once all previous publications have been considered, the authors' study complements them by incorporating new ROA stations, which will contribute to research on tectonic deformations in the region—an aspect of great significance.

Furthermore, I identify several methodological flaws and some errors, including: the methodology is not described in sufficient detail to enable replication and further research; not all time series graphs are provided, or some contain errors that hinder proper evaluation; the validation of results is poor; the rigor of the comparison method with previous publications is inconsistent with the level of precision or accuracy in the authors' statements and conclusions; key results, such as the calculated coordinates of the new stations, are missing, making it difficult or impossible to use the new velocity field; there is a lack of connection between the content of the study and some of the citations; and the reported horizontal velocities are incorrect, further affecting the geodynamic interpretation.

Considering that the authors provide results based on new ROA stations, which are not accessible to other researchers, it would be of great interest to the scientific community if they employed the double-differencing technique in future research to provide results with the highest possible precision. Furthermore, I suggest that, given the background on the quality of some ROA stations, the authors take into account the published findings and complement the quality assessment with new data. This information on data quality will help support the precision of their results and will also be valuable to other researchers.

Finally, it is important to note that GNSS software and processing techniques are constantly evolving, integrating improvements over time, and that the quality of a GNSS station may change over the years. Consequently, a result that is accurate and precise today may be less so in the future. However, it should be properly supported with as much relevant information as possible to ensure reliability.

Author Contributions: The author confirms sole responsibility for the following: conceptualization, methodology, software, validation, formal analysis, investigation, resources, data curation, writing—original draft preparation, writing—review and editing, and visualization. The author has read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: Data and resources used in this work are indicated in the main body. Figure 3b was created using GMT software version 5.4.5 [25].

Conflicts of Interest: The author declares no conflicts of interest.

References

1. Rodríguez Collantes, D.; Blanco Hernández, A.; de Lacy Pérez de los Cobos, M.C.; Galindo-Zaldivar, J.; Gil, A.J.; Sánchez Piedra, M.A.; Mastere, M.; Ouchen, I. A New Earth Crustal Velocity Field Estimation from ROA cGNSS Station Networks in the South of Spain and North Africa. *Remote Sensing* **2025**, *17*. https://doi.org/10.3390/rs17040704.
2. García-Armenteros, J.A. Topo-Iberia CGPS network: a new 3D crustal velocity field in the Iberian Peninsula and Morocco based on 11 years (2008–2019). *GPS Solutions* **2023**, *27*, 155. https://doi.org/10.1007/s10291-023-01484-8.
3. García-Armenteros, J.A. Topo-Iberia CGPS network: A new 3D crustal velocity field in the Iberian Peninsula and Morocco based on eleven years (2008–2019). *Research Square* **2022**. Preprint. https://doi.org/10.21203/rs.3.rs-1777869/v1.
4. García-Armenteros, J.A. Quality assessment of the Topo-Iberia CGPS stations and data quality's effects on postfit ionosphere-free phase residuals. *Geodesy and Geodynamics* **2024**, *15*, 189–199. https://doi.org/10.1016/j.geog.2023.07.006.
5. García-Armenteros, J.A. Quality assessment of the Topo-Iberia CGPS stations and data quality's effects on ionosphere-free phase residuals. *Research Square* **2023**. Preprint. https://doi.org/10.21203/rs.3.rs-2233625/v1.
6. Topo-Iberia CGPS network. Data quality. Daily Tracking Performances. Available online: https://blogs.ujaen.es/jgarmen/topo-iberia_data_quality (accessed on 19 March 2025).
7. García-Armenteros, J.A. Antenna environment's effects on elevation angle dependent ionosphere-free phase residuals, and geodetic monument noise in the Topo-Iberia CGPS network. *Research Square* **2024**. Preprint. https://doi.org/10.21203/rs.3.rs-3910259/v1.
8. García-Armenteros, J.A. 3D kinematics of the Iberian Peninsula and Morocco from time series of the Topo-Iberia CGPS stations (2008–2019): quality assessment, and processing strategy. PhD Thesis, University of Jaén, Jaén (Spain), 8 March 2024. https://hdl.handle.net/10953/2670.
9. Blewitt, G.; Lavallée, D. Effect of annual signals on geodetic velocity. *Journal of Geophysical Research: Solid Earth* **2002**, *107*. https://doi.org/10.1029/2001JB000570.
10. Garate, J.; Martin-Davila, J.; Khazaradze, G.; Echeverria, A.; Asensio, E.; Gil, A.J.; de Lacy, M.C.; Armenteros, J.A.; Ruiz, A.M.; Gallastegui, J.; et al. Topo-Iberia project: CGPS crustal velocity field in the Iberian Peninsula and Morocco. *GPS Solutions* **2015**, *19*, 287–295. https://doi.org/10.1007/s10291-014-0387-3.
11. Legrand, J.; Bruyninx, C.; Altamimi, Z.; Caporali, A.; Kenyeres, A.; Lidberg, M. Guidelines for EUREF Densifications, 2021. Available from Royal Observatory of Belgium: https://doi.org/10.24414/ROB-EUREF-Guidelines-DENS.
12. EUREF permanent GNSS Network. Reference station classification. Available online: https://epncb.oma.be/_productsservices/ReferenceFrame/Station_Classification.php (accessed on 19 March 2025).
13. Koulali, A.; Ouazar, D.; Tahayt, A.; King, R.; Vernant, P.; Reilinger, R.; McClusky, S.; Mourabit, T.; Davila, J.; Amraoui, N. New GPS constraints on active deformation along the Africa-Iberia plate boundary. *Earth and Planetary Science Letters* **2011**, *308*, 211–217. https://doi.org/10.1016/j.epsl.2011.05.048.
14. Fadil, A.; Vernant, P.; McClusky, S.; Reilinger, R.; Gomez, F.; Ben Sari, D.; Mourabit, T.; Feigl, K.; Barazangi, M. Active tectonics of the western Mediterranean: Geodetic evidence for rollback of a delaminated subcontinental lithospheric slab beneath the Rif Mountains, Morocco. *Geology* **2006**, *34*, 529–532. https://doi.org/10.1130/G22291.1.
15. Herring, T.A.; King, R.W.; Floyd, M.A.; McClusky, S.C. *Introduction to GAMIT/GLOBK. Release 10.7*; Department of Earth, Atmospheric, and Planetary Sciences. MIT, Cambridge, MA, 2018; p. 54. http://geoweb.mit.edu/gg/docs/Intro_GG.pdf.

16. Kreemer, C.; Blewitt, G.; Klein, E.C. A geodetic plate motion and global strain rate model. *Geochemistry, Geophysics, Geosystems* **2014**, *15*, 3849–3889. https://doi.org/10.1002/2014GC005407.
17. Altamimi, Z.; Métivier, L.; Collilieux, X. ITRF2008 plate motion model. *Journal of Geophysical Research: Solid Earth* **2012**, *117*. https://doi.org/10.1029/2011JB008930.
18. Altamimi, Z.; Métivier, L.; Rebischung, P.; Collilieux, X.; Chanard, K.; Barnéoud, J. ITRF2020 Plate Motion Model. *Geophysical Research Letters* **2023**, *50*, e2023GL106373. https://doi.org/10.1029/2023GL106373.
19. EUREF permanent GNSS Network. Position Time Series. Available online: http://www.epncb.oma.be/_productsservices/timeseries (accessed on 19 March 2025).
20. Borque, M.J.; Sánchez-Alzola, A.; Martin-Rojas, I.; Alfaro, P.; Molina, S.; Rosa-Cintas, S.; Rodríguez-Caderot, G.; de Lacy, C.; García-Armenteros, J.A.; Avilés, M.; et al. How much Nubia-Eurasia convergence is accommodated by the NE end of the eastern Betic shear zone (SE Spain)? Constraints from GPS velocities. *Tectonics* **2019**, *38*, 1824–1839. https://doi.org/10.1029/2018tc004970.
21. Herring, T.A.; King, R.W.; McClusky, S.C. *Introduction to GAMIT/GLOBK. Release 10.4*; Department of Earth, Atmospheric, and Planetary Sciences. MIT, Cambridge, MA, 2010; p. 48.
22. Dach, R.; Hugentobler, U.; Fridez, P.; Meindl, M. *Bernese GPS software version 5.0. User manual*; Astronomical Institute, University of Bern, 2007; p. 640.
23. Zumberge, J.F.; Heflin, M.B.; Jefferson, D.C.; Watkins, M.M.; Webb, F.H. Precise point positioning for the efficient and robust analysis of GPS data from large networks. *Journal of Geophysical Research: Solid Earth* **1997**, *102*, 5005–5017. https://doi.org/10.1029/96JB03860.
24. Bertiger, W.; Bar-Sever, Y.; Dorsey, A.; Haines, B.; Harvey, N.; Hemberger, D.; Heflin, M.; Lu, W.; Miller, M.; Moore, A.W.; et al. GipsyX/RTGx, a new tool set for space geodetic operations and research. *Advances in Space Research* **2020**, *66*, 469–489. https://doi.org/10.1016/j.asr.2020.04.015.
25. Wessel, P.; Smith, W.H.F.; Scharroo, R.; Luis, J.; Wobbe, F. Generic Mapping Tools: improved version released. *EOS, Transactions American Geophysical Union* **2013**, *94*, 409–410. https://doi.org/10.1002/2013EO450001.